Aus der Universitäts-Kinderklinik (Jennerspital) Bern
Direktor: Prof. Dr. E. Glanzmann

HYDROCEPHALY AND MICROCEPHALY IN INFANCY

INAUGURAL-DISSERTATION

zur
Erlangung der Doktorwürde
der Medizinischen Fakultät
der Universität Bern

vorgelegt von

Leonard Cutler

von Brooklyn, N.Y., U.S.A.

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BIBLIOTHEEK
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Von der Medizinischen Fakultät auf Antrag des Herrn Prof. Dr. E. Glanzm
zum Druck als Dissertation genehmigt.

Bern, den 17. Dezember 1955

Der Dekan der Medizinischen Fakultät:

Prof. Dr. med. W. Wilbrandt

INTRODUCTION AND DEFINITION OF TERMS

Hydrocephalus is the all-inclusive term for the abnormal accumulation of cerebrospinal fluid within the intracranial cavity due to a great variety of pathogenetic processes and pathological changes. The increased fluid may be confined to the ventricles, causing ventricular dilatation, may be in the subarachnoid space, or it may extend throughout the entire fluid system. Ventricular dilatation by increased fluid is also termed hydrops ventriculi. [52]

The hydrocephalus may be either the congenital form, known as congenital hydrocephalus, or it may be the acquired form, known as acquired hydrocephalus. However, this classification cannot be applied too rigidly, and it often fails to consider the essential nature of the condition. It cannot be applied temporally because many of the so-called congenital hydrocephalies are latent at the time of birth and first make their clinical appearance sometime after birth. From an etiological point of view, it does not take into account that the so-called acquired hydrocephalus may be the product of damage to the fetus during its intrauterine development which is first made evident after birth by a precipitating factor such as infection or trauma. However, in spite of its limitations, this classification will still be maintained for the purpose of presentation. Congenital hydrocephalus will be considered as those cases in which the hydrocephalic fluid accumulation develops intrauterine and those cases which appear shortly after birth without any clinically apparent precipitating factor. Those cases which appear in early infancy or childhood as the result of a demonstrable pathological process will be considered acquired hydrocephalus.

Hydrocephaly occurring in infancy usually produces a varying excessive enlargement of the skull which may reach an enormous extent. However, the abnormal fluid accumulations may often occur with the skull retaining its normal size, or even being abnormally diminished in size. Koeppe [33] referred to the condition of hydrocephalus without abnormal enlargement of the skull as Hydrocephalus occultus. In those instances where there is an increased amount of cerebrospinal fluid in a patient with an abnormally small head, microcephaly, the condition has been called hydromicrocephaly. [41]

This term was used by Zappert, [58] Ballantyne, [3] von Bokay, [7] and von Reuss, [45] all before the introduction of encephalography. Zappert wrote: "Hydromicrocephaly is the term used to designate a malformation in which the external skull is diminished in size instead of enlarged and the brain itself is represented as a watery cyst . . ." Von Reuss also pointed out that the external circumference of the skull in congenital hydrocephalus is not necessarily enlarged, and that it may even

be abnormally small, presenting the characteristic shape of microcephaly. called this condition hydromicrocephaly. Mc Clelland [29] described thirte cases, all of whom showed dilated ventricles and closure of the anterior fonta with microcephaly. He felt that, "the cases resemble one another so closely t it appears proper to group them in a single syndrome under the name of hyd microcephaly." [4]

It has been stated that acquired hydrocephalus is synonymous with serous me ingitis, [29] but it is the opinion of most authors that these two conditions are identical. [28, 52] Meningitis serosa is a clinical condition which expresses its as an affection of the meninges with serous exsudation. It is characterized by creased cerebrospinal fluid pressure on lumbar puncture, but the fluid is other qualitatively normal. This condition may be local or diffuse and usually occ following infections, especially otitis media, and following trauma to the hea Acquired hydrocephalus, on the other hand, is a secondary manifestation symptom of an underlying disease process.

These cases of hydrocephalus in which it is not possible to demonstrate a causat lesion in the brain and meninges, or anywhere else in the body, have been d ignated as idiopathic hydrocephalus. However, more recent investigations ha shown that the primary, or essential, or idiopathic hydrocephalus is a condition very unusual occurrence. [28, 37] Wechsler, although he still maintains the ter questions whether all forms of hydrocephalus are not a secondary result of so underlying pathological process. [52]

Hydrocephalus ex vacuo is that form of hydrocephalus in which the fluid is increa in amount in the sense that if fills out the space where brain tissue has been l down defectively, or where the tissue has degenerated. In this form, press symptoms rarely occur since there is an equilibrium between liquor production a resorption. Since the microcephalic form of hydrocephalus is due to a deficit brain tissue rather than to an imbalance between production and absorption fluid, or to an obstruction, it may be considered as a hydrocephalus ex vacuo.

The concepts of external and internal hydrocephalus, communicating and n structive hydrocephalus, and hypersecretory and hyporesorptive hydrocephalus w be considered in the section on pathogenesis after a consideration of the norm physiology and circulation of the cerebrospinal fluid.

NORMAL DEVELOPMENT OF THE SKULL

There is a considerable increase in the circumference of the infant's head in the first year of life due to the extremely rapid growth of the brain. At birth the brain weight averages 350 grams, and at the end of the first year it weighs two and one-half times as much. [56] It is, therefore, of importance that the infant's head circumference be measured at regular intervals, for it will provide valuable aid in evaluating brain growth and detecting any abnormal enlargement or diminution in size. This measurement is of greatest value during the first year of life, of little value after two years, and need not be taken after three years. It is determined by applying a measuring tape anteriorly over the glabella and supraorbital ridges and posteriorly over that part of the occiput which gives the maximum circumference. These measurements are then compared with those of normal development. (See table 1). The usual head circumference at birth is 35.3 cm., in the third month it is 40.9 cm., in the sixth month 43.9 cm., in the twelfth month 46.5 cm., and at the end of the second year 49.7 cm. [50]

It is also of value to measure chest circumference in addition to head circumference for the purpose of comparing the two values and noting any discrepancies between them. It should be noted, however, that there are two variables present and that one must consider that a discrepancy may be due to an abnormal chest measurement as well as to an abnormal head. At birth the head circumference is approximately one centimeter larger than the chest circumference, and during the early weeks there is a more rapid enlargement of the head than the chest. Thereafter, chest enlargement takes place more rapidly so that the head circumference is larger during the first year, but at the age of one year they are approximately equal. Thereafter, the relation of the head circumference to the chest circumference decreases progressively.

TABLE 1. Average Circumferences of the Head and Thorax in the First Five Years of Life. [50]

Age	Head	Thorax
Birth	35.3 cm	35.0 cm
3 months	40.9 "	40.0 "
6 "	43.9 "	43.7 "
9 "	46.0 "	46.0 "
12 "	47.3 "	47.6 "
18 "	48.7 "	49.6 "
2 years	49.7 "	50.8 "
3 "	50.4 "	52.4 "
4 "		53.7 "
5 "		55.0 "

The measurements of the head circumferences in the above table correspond ve closely to the normal values given by Heubner [30] and Glanzmann. [24]

Although the cranial sutures may appear closed at birth, ossification does n occur until late childhood, or early adulthood. However, in the presence of an a normal increase in the size of the cranial contents, such as in hydrocephalus, th separate very easily. In microcephaly, on the other hand, there is a prematu synostosis of the sutures. The anterior fontanel has an average diameter of abo 2.5 cm. during the first few weeks of life. For the first two or three months it m increase in size, but thereafter it should begin to diminish in size and to ossify. usually closes at about one year of age and normally should be closed by the fi teenth month. An anterior fontanel which is usually small, or one which clos prematurely, is suggestive of microcephaly. A delay in closure of the fontanel m occur in hydrocephalus, rickets, cretinism, and mongoloidism. The posteri fontanel, which is of less clinical significance, usually closes within the first fe months, most often in the third or fourth month. However, it may be closed in t first or second month, or as late as the sixth or seventh month.

PHYSIOLOGY OF THE CEREBROSPINAL FLUID

The function of the cerebrospinal fluid is primarily that of mechanical protecti for the nervous substance of the brain and spinal cord. It also serves to mainta a constant pressure within the central nervous system and may serve a metabol function in that there is probably an exchange of metabolic substances betwe the fluid and the nervous tissue. [5] The fluid circulates within a closed syst consisting of the ventricles of the brain, the spinal canal, and the subarachno spaces with their dilatations at the base of the brain, the basal cisternae. Sin the work of Dandy, [14-19] it is generally agreed that the liquor is produced mo or less continuously by the choroid plexus, but there is also suggestive evidence th the perivascular spaces, especially of the arterial capillaries of the pia, and t ependymal cells of the ventricles may also take part in this process. [5] The flu flows from the lateral ventricles through the foramen of Monro into the thi ventricle, and then through the aequaduct of Sylvius into the fourth ventricle. escapes from the fourth ventricle through the foramen of Magendie and the forami of Luschka into the subarachnoid space where it reaches the basal cisternae, e pecially the cisterna cerebello-medullaris (cisterna magna). From here the flu passes downward to the spinal subarachnoid space, and it passes upward to the co vexity of the cerebral hemispheres. The fluid is removed mainly by diffusion throu the arachnoid villi (Weed [53]) into the venous sinus and the general circulatio

although according to Dandy, [14, 19] it may also pass directly into the capillaries of the pia-arachnoid, or be absorbed through the perivascular lymph spaces and the perineural lymph sheaths.

ETIOLOGY AND PATHOGENESIS

From the preceding discussion, it is apparent that any imbalance between the production and absorption of fluid, or any obstruction to the flow of the fluid, will cause an abnormal fluid accumulation. If the increased amount of fluid is confined to the ventricle system, it is called hydrocephalus internus, and if confined to the subarachnoid space it is known as hydrocephalus externus. It is also possible that both types, hydrocephalus externus and internus, may occur concomitantly.

Any obstruction in the path between the ventricles and the subarachnoid space is known as obstructive or occlusive hydrocephalus. The possible causes of such an occlusion are numerous. It may be a tumor or cyst of the cerebrum, or a space occupying lesion in the region of the posterior cranial fossa which, by direct pressure, can cause closure of the aqueduct of Sylvius and the foramen of Magendie. In addition, congenital atresias, blood clots, parasites, tubercles, encephalitis, adhesions and scars as a result of meningitis can all cause a passage obstruction. [28] The closure may be either partial or absolute. The most frequent cause, according to Dandy, [17] is stricture of the aqueduct of Sylvius which is the result of an inflammatory or post-traumatic adhesion, and usually congenital in origin. Of less frequency, and usually occurring after birth, is the occlusion of the foramina of Magendie or Luschka due to a basal meningitis. Tumors may produce these same effects. Infrequently, it is also possible to have a unilateral hydrocephalus as the result of closure of one of the foramina of Monro. An internal hydrocephalus of the obstructive type, which is present at birth or appears shortly afterward, may be a clinical manifestation of toxoplasmosis.

In contrast to obstructive hydrocephalus, is the hydrocephalus resulting from an obliteration of the subarachnoid space in the area of the basal cisterna, which is known as communicating hydrocephalus. The most frequent cause of a communicating hydrocephalus is a basal meningitis. The basilar adhesions are especially found around the brain stem at the point where the latter passes through the opening of the tentorium, and here the cisterns are obliterated. [37] In this form, a dye stuff injected into the ventricles can be recovered a short time (thirty minutes) later in the spinal fluid removed by a lumbar puncture. In obstructive hydrocephalus the spinal fluid remains clear.

In addition to the classification according to whether the circulatory system is patent or occluded, Dandy and Blackfan [18, 19] suggested the concept of hypersecretory hydrocephalus and hyporesorptive hydrocephalus, according to whether there was an increased production of fluid or a decreased absorption. In both the communicating and obstructive hydrocephalus there is a diminished absorption of cerebrospinal fluid, but the hyporesorptive hydrocephalus (Hydrocephalus non resorptus of Kruse [35]) is considered to be a distinct entity. This form is caused by obliteration, or primary developmental anomaly of the subarachnoid space in its extension over the cerebral convexity and of the arachnoid villi [35, 37]. Such an obliteration of the subarachnoid space could occur as the result of meningitic adhesions [22] and adhesions following a hemorrhage [39, 28].

The importance of the role of overproduction of liquor as a cause of hydrocephalus is still not definitely determined. The existence of hypersecretory hydrocephalus is denied by de Lange [36]. On the other hand, Brenner [7] claims that a number of cases of hydrocephalus resulting from epidemic meningitis are mainly due to a hypersecretion of fluid. Under normal conditions, as stated previously the cerebrospinal fluid is produced by the choroid plexus, with a certain role possibly being played by the ventricular ependyma. Under pathological conditions meningeal exudation and vascular transudation can result in the production of an increased amount of fluid in the subarachnoid space and the ventricles. It is also probable that the choroid plexus reacts with an increased liquor production [28]. The inflammations of the meninges and choroid plexus which cause increased fluid production may be bacterial or abacterial in nature, diffuse or circumscript in localization, and acute or chronic in course. To the bacterial group belong primarily the chronic forms of tuberculous and syphilitic meningitis. The most frequent cause, however, of increased fluid production is due to abacterial inflammatory changes in the meninges. This may be considered the same as the serous meningitis of Quincke [28]. Serous meningitis may be produced by almost all the infectious diseases, by infectious processes in close proximity to the meninges such as otitis media and sinusitis, by infected scalp wounds, encephalitides, abscesses, and tumors, and it may occur after trauma to the head.

All processes in which, as a result of atrophic or degenerative changes, there is a loss of nerve substance result in a secondary dilatation of the liquor spaces and replacement of the brain substance with cerebrospinal fluid. This type of hydrocephalus cannot be included in Dandy's classification of obstructive, communicating, hyporesorptive, and hypersecretory hydrocephalus and, as stated previously, is known as hydrocephalus ex vacuo. This group also includes the dysgenetic form of hydrocephalus which is the result of an inhibitory developmental anomaly. This form of hydrocephalus is sometimes associated with other congenital anomalies,

in particular spina bifida. The cause of the simultaneous occurrence of these two conditions is not known, but when they do occur together, the hydrocephalus is not secondary to the spina bifida. [37] Brenner [9] is of the opinion that hydrocephalus following encephalitis is ex vacuo in nature.

Another important group which can be considered as falling within the group of hydrocephalus ex vacuo is the combination of hydrocephaly with microcephaly, sometimes known as hydromicrocephaly. Concerning the origin of microcephaly, the old atavistic theory of C. Vogt and the theory of premature synostosis of Virchow, popular for a long time, have now become untenable. [25, 55] In fact, the skull anomaly is a secondary result of the failure of the brain to grow properly, and it has been shown that the synostosis of the sutures may even be absent in adult microcephalics. [32] It is generally agreed that there are both endogenous and exogenous factors which may be responsible for causing microcephalus, and, accordingly, the concepts of microcephalia vera or pura and pseudomicrocephaly are often used. [40] By microcephalia vera is generally meant a developmental defect on the basis of a constitutional predisposition without any demonstrable pathologic changes in the brain substance which would explain the smallness of the brain. In this respect, von Monakow [42] says, "The smallness of the brain in such cases is the result of a primary general or partial dysgenesis, respectively dysplasia of the medullary tube as well as the resulting consequences in respect to the tectonic differentiation of the individual layers." He considers the dilatation of the ventricles and the hydrocephalus ex vacuo as a morphological adjustment to the hypoplastic, aplastic, and degenerative processes which are taking place. On the other hand, Benda [4] believes that the hydrocephaly is not due to the enlargement of the ventricles, but due to the failure of the primitive brain vesicles to decrease in size because of lack of development of the white matter. Pseudomicrocephaly refers to the developmental defect resulting from an external disturbance, of mechanical, toxic, radiological, or infectious nature, which affects the fetal brain during its intra-uterine development, and which permits the demonstration of distinct localized pathological changes such as hemorrhages, cysts, liquefactions, sclerosis, and inflammatory processes in the brain and meninges. However, the possibility should be borne in mind that such a process, which existed at an early time, caused a disturbance in the developmental process and then disappeared completely during the further growth so that it is no longer morphologically demonstrable. [42] Even though no intra-uterine illness of the fetus can be clinically demonstrated and the pregnancy may have been clinically normal, it still cannot always be assumed that the sole cause lies in the germ plasm because it is sometimes possible to demonstrate by exact histological examination the remains of old hemorrhages or inflammatory processes. [32]

The role of radiation of the maternal uterus during the early months of pregnanc as a cause of damage to the fetal brain with consequent microcephaly and hydro cephaly has received considerable attention. Zappert [52] is of the opinion tha irradiation of the uterus taking place during the early months of gestation wil cause microcephaly in fifty percent of the subsequent births, and Murphy [43, 44] in a review of the effect of radiation of the ovaries on subsequent offspring, foun that sixty-one percent of the offspring following such irradiation are defective; however he does not believe that irradiation prior to fertilization has any harmfu influence upon the health of any subsequent offspring. These observations hav been corroborated by numerous reports in the literature of microcephaly followin radiation of the fertilized ovum with therapeutic dosages.

Fincher [21] believes that birth trauma may be a definite factor in some cases o microcephaly where, on exposure, a thickened purple tinged membrane is foun adherent to the inner surface of the dura. This membrane is similar in appearanc and may be considered analogous to the membrane of pachymeningitis hemorrhag- ica, or chronic subdural hematoma, found in adults. This membrane in infant may be a factor in the failure of the cerebrum to expand, and it may be a secon- dary factor in the production of certain histological changes.

Emphasizing the endogenous or heredity origin of the microcephalic-hydrocephalic malformation is its occasional tendency for familial occurrence as shown by the numerous reports of such cases in the literature. [60, 56, 57, 11, 21, 1] Although these observers feel that it may be an inherited characteristic, the exact type of inheritance involved is not known, except that it is considered to be a recessive trait. It is indeed possible that all these factors, hereditary and environmental, endogenous and exogenous, may play etiological roles and that the hereditary inner factors render the fetus especially susceptible to adverse influences during its intra- uterine development.

PATHOLOGICAL ANATOMY

The pathological-anatomical changes in the various forms and manifestations of hydrocephalus are extremely varied in extent, type, and severity. They are ob- viously dependent on the cause, on the time of onset of the illness, and the length and intensity of its course. The change common to all forms, and the basis of definition of the condition, is the dilatation of the cerebral ventricles which may be only slight or extremely extensive in degree. The changes are usually bilaterally symmetrical, but may occasionally be unilateral and asymmetrical as, for example, in an obstruction of the foramen of Monro. The dilatation of the ven- tricles occurs only at the expense of the brain substance so that the cortex may

undergo considerable thinning. In those forms with increased intracranial pressure there may be an extensive flattening of the sulci and gyri with a consequent disappearance of the normal surface relief. In extreme cases the brain may be represented only by a large fluid filled cyst. The third ventricle may also be dilated with its floor showing a special tendency to protrude and compress the optic chiasma and hypophysis. The fourth ventricle, apparently because of mechanical relationships, is usually involved in the general dilatation only to a limited extent. However, when there is closure of the foramina of Luschka and Magendie, it may also undergo considerable dilatation which is usually expressed as a protrusion of the roof backwards and downward (Dandy). The corpus callosum and septum pellicicum become thinned, and the basal ganglia are flattened. The foramen of Monro and the aquaduct of Sylvius may be dilated in the communicating form. The ependyma in the dilated ventricles may be thickened and granular, or it may appear normal. The cerebellum may occasionally show extensive atrophic changes. The meninges are usually unchanged with the exception of those cases where there is a serous or purulent meningitis present.

Histologically, in the chronic forms the glia is extensively increased. The cortex hypoplasia is evidenced by the lack of, or only slight indication of, differentiation of the layers and the atypical form of many ganglion cells which maintain their round embryonic form (Anton) [2].

In the microcephalic forms, the cerebral hemispheres also show the greatest deficiency, with the cerebellum being affected to a much lesser extent. There is usually an extensive, rather regular decrease in size of all parts of the cerebellum. Microgyria and agenesis of the cortex are found in most cases, and there is a hypoplasia of almost the entire cortex, especially in the parietal and occipital lobes. [43] A numerical loss of convolutions is unusual, but they may vary profoundly in size and shape, and, occasionally, the secondary sulci are found to be absent.

The architectonic structure of the cerebral hemisphere shows a poor differentiation of the cellular layers and of the cells themselves with a paucity of neurones, suggesting a fixation of development at an embryonic phase. [10] Other signs of developmental disturbance of the cortex such as gliosis, heterotopia, and inadequate myelinization can also occur. In a case described by Benda [4], which was caused by a prolonged asphyxiation following brith, the picture was that of a normal full term brain in regard to its convolutional and fissural patterns, the development of the cortical areas, and the fiber myelinization. In this instance the chief pathological feature was an extensive necrosis and cystic degeneration of the white matter with a corresponding ventricular dilatation. The meninges are usually of normal appearance, but, in the cases examined by Brushfield and Wyatt [12], the meninges showed signs of chronic inflammatory change with the dura being thickened and occasionally adherent to the pia-arachnoid.

As a result of pressure from the enlarged temporal squama, the ears appear to be situated lower, the ear lobe may be displaced horizontally, and the external auditory meatus may be narrowed to the form of a slit. The posterior part of the head may be flattened as a result of pressure when the patient lies on its back. The cranial bones are considerably thinned, and the diploe may often be lacking, so that on palpation the skull feels elastic, or may even give a parchment-like sensation. The fontanelles are enlarged and tense, so that no underlying pulsations are palpable. The tension of the fontanelles is usually further increased by crying of the child. The cranial sutures are usually widely separated. In contrast of the large cranial vault is the small face which appears as a triangular appendage hanging from the cranium. The scalp veins, especially in the temporal and parietal regions, are distended, owing to the drainage of the intracranial circulation through the emissary veins into the extracranial circulation, and appear as thick blue strands. The scalp and skin are tensed and atrophic, and the hair is very sparse. A classical description of this characteristic appearance was that of Ibrahim [31]: "The head is out of proportion to the body, the scalp is thin, the hair sparse, the veins are prominent; the face appears small and triangular; the frontal bone arches down to the root of the nose; the sockets of the eyes are widely separated; the temples overhang; the sutures are wide; the fontanells are tense; the eyeballs converge, and are near the internal canthi; the sclerae are visible." In spite of the strong development of the neck musculature the child is unable to hold its head up, and when placed in a sitting position the large head falls forward or to the side. Occasionally, the child may utter a sudden loud cry (cri hydrocéphalique) which is not always to be considered as an expression of pain, but may be considered as reflex crying." [28]

Severe cranial nerve symptoms seldom occur, but there may occasionally be a strabismus, slight occulomotor paresis with ptosis, abducens paresis, nystagmus, or inadequate pupillary light reflex. Papilledema and optic neuritis are very unusual. As a result of cerebral disturbances, the child is feable, and the motor functions are significantly diminished. There may be a paresis, hemiplegia, or spastic paraplegia, the spastic phenomena being especially characteristic, but, infrequently, there may be absence of deep tendon reflexes. [27] The legs are especially affected, so that the child learns to walk late, or not as all, or it may lose the ability to walk. Contractures often form, especially of the adductors of the leg, with a tendency for the legs to cross. The abdominal reflexes are not characteristic. In addition to these mobile disturbances, the hydrocephalic children show a characteristic lethargy and aversion to movement. There is often urinary and anal incontinence, probably as a result of the mental condition, but it may also be a paralysis symptom. Tremor and ataxia occur not infrequently, and there may be convulsive phenomena of tonic or clonic, local or general nature.

Sensibility is usually intact. Trophic disturbances are usually lacking. Frequently the hydrocephalus is complicated by other developmental anomalies such as encephalocele, spina bifida, club foot, hare-lip, albinism, and polydactyly. Occasionally, hypophyseal symptoms may be observed as a result of pressure by the distended floor of the third ventricle on the pituitary, infundibulum, and the hypothalamic region. The children usually have a definite sickly general appearance. They are pale, then, have a senile appearance, cry a great deal, and do not gain weight properly, although the appetite may not be disturbed, or even increased. The patient becomes dull and listless, and the intellectual and mental capacities usually suffer extensively, with all degrees of mental deficiency occurring, and idiocy and imbecility being not uncommon. A normal intelligence seldom occurs, and it may be mentioned that rare cases have been described in which there was an extremely brilliant mental capacity accompanying hydrocephaly. Thus, it has been stated that Edison, Schopenhauer, Beethoven, Wagner, Gottfried Keller, and Hemholtz all had hydrocephaly. [28, 29]

The cerebrospinal fluid is increased in quantity in comparison to the normal amounts of 5 cc. in the newborn and 100-150 cc. in the adult [46], and there may be as much as one, two or, in extreme cases, five liters present. [58] The contents usually correspond to that of normal fluid. It is clear, colorless, and the number of cells usually remains within normal limits. The fluid pressure is usually within normal range, although in some cases it may be elevated.

The prognosis of congenital hydrocephalus is poor, but depends on the degree of the latter and the severity of the clinical symptoms. Most cases which survive birth usually die during the first year of life. The infant does not grow, becomes cachectic, and dies of an intercurrent infection, or, less often, as a direct result of increased intracranial pressure causing respiratory paralysis. The cranial growth may continue progressively until death, may cease permanently, or may cease temporarily to recommence after a varying period of time. Although, in mild cases, the mental and physical development may proceed favourably, the majority of cases which manage to survive are mentally deficient and show inadequate motor function. Exceptionally, even an extensive hydrocephaly may survive until adulthood, and numerous such cases are reported in the literature. A cessation of cranial enlargement is not necessarily followed by an improvement of the physical and mental condition, because progressive mental deficiency may occur without progressive hydrocephaly. In all cases there is a danger of future exacerbations. Spontaneous arrest as a result of resorption of fluid or leakage of fluid through the nose, hydrorrhea nasalis, is rare.

When accompanying the hydrocephalus, the head, instead of being enlarged, is diminished in size, an entirely different picture is produced. It is now the picture

of hydromicrocephaly. The characteristic reduction in the size of the skull affec primarily the cranial vault, while the skull base is generally reduced only to a slight extent. All the cranial dimensions are decreased, but especially the horizontal circumference, the interparietal diameter, the skull height, and the auricular arch. 51) The relationship between the frontal diameter and the interparietal diameter, known as the transverse fronto-parietal index, becomes relatively increased. 40) The facial part of the skull, including such dimensions as the ear-chin line and the width of the zygomatic arch, is affected to a much lesser extent and is usually within normal physiological limits. Thus, the normal face is relatively large in comparison to the small cranium, and it is this misproportion which explains the peculiar head form, and which is most striking on consideration of the microcephalic head. This misproportion may become further accentuated as growth proceeds since the facial portion and the skull base grow normally, whereas the cranium is retarded in its growth, or fails to grow at all. The microcephalic head is further characterized by a narrow, rapidly receding forehead, a somewhat pointed vertex, a flattened occiput, a large prominent nose and simian type of chin. The frontal bone may undergo certain other characteristic changes in that the region of the frontal suture may show a ridge-like eminence, the supraorbital margin may be thickened in a ridge-like manner, and the superciliary arch may extend to the zygomatic process of the frontal bone. There is a characteristic premature synostosis of the sutures, specially of the sagittal suture, but the sutures may be retained as in normal skulls. 40) The anterior fontanel may be closed at birth, or it may close during the early months of life. Sometimes the scalp may be hyperplastic in relation to the small cranium so that there is a resulting formation of ridges and grooves in the occipital and parietal areas. The rest of the skeleton is usually normal, but there may be long arms and legs, large ungainly hands and feet, or the patient may be unusually small and underweight. These latter cases show a retarded body development. They grow slowly, learn to walk late, if at all, and their weight remains abnormally low. Some cases may never learn to stand or walk, possibly because of both motor defects and mental deficiency. Genital abnormalities such as underdevelopment, and cryptorchism are often observed. Sensory functions are usually normal, but motor disturbances often occur. Soon after birth there may be a noticeable lethargy and immobility or a marked restlessness. There may be a general muscular weakness and flaccidity so that the infant is unable to hold its head up, or there may be a generalized muscle rigidity, and the infant may show a spastic paresis or paralysis. In the latter case, the arms are pressed on the thorax, the elbows are bent, the hands palmar flexed, the fingers bent, the legs extended, and strongly adducted with a tendency to cross, and the trunk muscles extremely rigid. 4) The reflexes are hyperactive. Convulsive seizures of general or local nature are frequently present. There may be various

degrees of optic atrophy with defective vision or blindness which is accounted for by failure of the optic foramina to enlarge proportinately with the growth of the optic nerves, thereby resulting in constriction and atrophy. The cerebrospinal fluid shows no abnormal changes with the exception of a relative increase in amount.

Almost all cases show mental deficiency of varying degree with the majority ranging from the trainable middlegrade imbecile to the profound idiot who can hardly be elevated above the level of a vegetative existence. The child may be completely uninterested in its environment and it is noted for its lack of the characteristic smiling and other facial expressions of the normal infant.

DIAGNOSIS

The diagnosis of hydrocephalus in the classical advanced case with the enlarged, deformed skull is obvious at a glance. The typical advanced microcephalic deformity is also obvious on inspection, but the demonstration of ventricular dilatation in this form and in the form where no skull changes are present requires the use of special diagnostic procedures. Such special procedures are also necessary for determining the type and extent of the hydrocephalus. On physical examination the following signs may be elicited:

(1) increased tension of the anterior fontanelle, which is indicated by the absence of normal depression and pulsation with a persistent fullness or elevation of the fontanelle when the infant is held in the erect position and is not straining or crying;
(2) either a separation of the sutures in the macrocephalic form, or a narrowing and premature synostosis in the microcephalic form;
(3) either a progressive prominence of the frontal bone, or a recession of the frontal bone;
(4) a change in the size of the anterior fontanel, (average diameter 2.5 cm) with it being abnormally wide or abnormally small;
(5) beginning prominence of the scalp veins in the enlarged form;
(6) feeding problem;
(7) discrepancy between the head circumference and the chest circumference, with the head circumference being either larger or smaller, and the disproportion increasing after repeated measurements over a fourteen day period;
(8) a dullness or irritability of persistent nature;
(9) a cracked-pot tympanitic percussion sound, called Mac Ewen's sign, which may be elicited in the macrocephalic form. [47]

This percussion sign, however, is of doubtful value, and Greenwood [26] claim that it is present only after the brain substance has thinned out to less than on centimeter.

An early method used for the determination of ventricular dilatation, even in th absence of skull enlargement, was the transparence examination of Strassbur ger [48]. By placing a strong lamp behind the head of the patient in a dark room the cases of hydrocephalus were found to be transparent and allowed the light to shine through as a reddish glow. This method is limited in its usefulness in that i is only positive when the brain substance is thinned to at least one centimeter. [7] Although the transparency examination has been gradually replaced by encephalography, von Bokay [8] was of the opinion that the former should not be considered obsolete. He felt that it could be applied in certain cases of hydrocephaly and hydromicrocephaly with a completely positive diagnostic result, obviating the necessity of encephalography.

A simple x-ray film of the skull is not sufficient for diagnosis for it does not allow differentiation of the ventricles from the brain substance. However, it may show certain suggestive changes as a result of secondary changes in the bones of the skull. Accordingly, there may be changes in the configuration of the cranium or the base, and a thinning of the bones of the cranium, sometimes to a very striking degree. There may be pressure atrophy in the area of the sella turcica and changes in the sella itself so that the entrance is widened and the dorsum sellae is thinned and shortened. These sella changes occur especially with dilatation of the third ventricle, and are usually not present in communicating hydrocephalus in children. There may also be present an accentuation of the digital impressions, the Pacchionian depressions, and the vessel furrows, but these changes occur only when there is increased intracranial pressure. [37]

A roentgenographic visualization of the ventricles and their differentiation from the surrounding brain substance is only possible by the use of a contrast medium of lesser or greater density. Air, a medium of lesser density, is most commonly used. By means of the extent of filling and the form of the visualized ventricles and subarachnoid space, it is possible to draw accurate conclusions concerning the presence of hydrocephalus, extent of fluid accumulation, its location, and the type of hydrocephalus present. It is the best method for confirmation of the presence of occult hydrocephalus. The contrast visualization may be accomplished by either ventriculography or encephalography. In the ventriculogram, a needle is inserted through the brain substance into the lateral ventricle, fluid is withdrawn and replaced with air which permits easy demonstration of the entire ventricular system by roentgenographic examination, but the cisterns and subarachnoid space are generally not filled by this method. In the encephalogram, the subarachnoid space

is entered by lumbar or suboccipital puncture, small amounts of liquor are withdrawn and replaced with air. Air introduced in this manner fills the ventricles indirectly, rendering them visible, as well as the subarachnoid space and the basal cistern. This method may be used only when there is no evidence of increased intracranial pressure because of the danger of herniation of the brain stem into the foramen magnum with death from respiratory paralysis. In the obstructive form of hydrocephalus the ventricles will be only partially, or not at all, visualized, depending on the site of the obstruction.

Another diagnostic aid in determination of the type of hydrocephalus present and in testing the patency of the liquor circulation system is the injection of dyes into the liquor system. The dye, which may be neutral phenosulphonphthalein , methylene blue, or indigo carmine, is injected into the lateral ventricle by means of a ventricle puncture which is then followed by a lumbar puncture. The dye should appear in the opposite ventricle immediately and in the lumbar cerebrospinal fluid after three to five minutes in a communicating hydrocephalus. A delay of twenty minutes indicates partial obstruction, and in total obstruction the dye will fail to appear at all. Determining the presence or absence of the dye in the cisternal fluid by means of suboccipital puncture will reveal whether the obstruction lies between the lateral ventricle and the cisterna magna or between the cistern and the lumbar space. Also, by determining the concentration of dye in the urine after certain periods of time, information may be obtained as to the resorption capacity of the subarachnoid space when a free communication has been shown to be present.

The dye studies and ventriculogram may be done as part of a general intracranial diagnostic puncture. In this procedure a needle is inserted through the brain substance until the lateral ventricle is reached. The ventricular fluid pressure is then measured with a water manometer. Normal ventricular pressure in an infant is 50 to 100 mm. of water with 150 mm. being considered as excessive and 300 mm. as a serious elevation. An approximate measure of the thickness of the cortex and white matter is obtained from the measurement of the depth of penetration of the needle less one centimeter to account for width of scalp and bone. Fluid is removed slowly for chemical analysis, and the air and dye studies may then be carried out.

It is also possible to visualize the ventricles directly by means of an encephaloscope [20]. It allows recognition of the ventricle wall, its blood vessels, the choroid plexus, and the foramen of Monro, as well as evaluation of the size of the ventricle. However, the procedure is not without danger, and the finer pathological changes are difficult to evaluate [28]. It has, thus, not come into general use because the same information and diagnostic results may be obtained with the simpler, less dangerous procedures.

An attempt to correlate electroencephalographic findings with ventricular dilatation was made by Levin and Greenblatt. 38) In a series of sixty-seven cases with unequivocal pneumoencephalographic evidence of ventricular dilatation many normal EEG's were found, and only forty-four percent of the cases had abnormal EEG's, but in these abnormal cases no specific pattern was found.

THERAPY

A complete discussion of treatment in the various forms of hydrocephalus would be beyond the scope of this paper, and, therefore, only short mention shall be made of some of the therapeutic principles involved. If the infant seems to be behaving normally, if he is eating well, and ventricular pressure is under 150 mm. of water, non-surgical therapy could justifiably be attempted. Non-operative measures seem to be particularly indicated in the case of communicating hydrocephalus with normal resorption of fluid demonstrated by diagnostic studies. 49) The conservative therapy of hydrocephalus includes the following measures: limitation of fluids; diuretics; drugs such as atropine to inhibit fluid secretion by the choroid plexus; radiation of the choroid plexus; postural drainage in a sitting position; and repeated ventricular taps. There should be a satisfactory response to conservative therapy within one month, and it should be promptly abandoned if there is a progressive increase of ventricular pressure or a rapid enlargement of the skull circumference. In the majority of cases conservative measures are without effect.

Surgical therapy seems to be indicated when conservative measures are ineffective; when there is an initial elevated intraventricular pressure over 250 mm. of water; when diagnostic studies indicate the presence of an obstructive hydrocephalus. Surgery can be considered to be contraindicated when there is an excessively enlarged head over 50 cm. in diameter; when the remaining thickness of cortex and white matter is less than 1 cm.; when an associated congenital defect of serious nature is present; when there is a poor mental status. 47)

There are numerous operative procedures described in the literature, many of which have been abandoned, and at present there is no known operative procedure which gives satisfactory results in a majority of cases over a five year follow-up period. Some of the operations suggested include: choroid plexus coagulation or extirpation; third ventriculostomy in which an opening is made in the lateral wall of the dilated third ventricle, permitting the fluid to escape into the basal cisterna; Torkildsen's procedure in which one end of a rubber catheter is inserted into the occipital horn of one ventricle and the other end, after running subcutaneously over the occipital lobe, is inserted into the cisterna magna; ventriculoperitoneal

shunt in which fluid is shunted through polyethylene tubing from one of the lateral ventricles into the peritoneal cavity; lumbar subarachnoidal-peritoneal shunt in which the lumbar subarachnoid space drains via polyethylene tubing into the abdominal cavity; the shunting of ventricular or lumbar subarachnoid fluid into a ureter; and ventriculomastoidectomy in which a connection is created, by means of polyethylene tubing, from the temporal horn of a lateral ventricle through the mastoid antrum, the middle ear, and the Eustachian tube into the nasopharynx. In addition to these, various other miscellaneous operations have been devised.

CASE REPORTS

CASE 1:

The patient, M.C., is a female infant admitted to the Jenner Kinderspital January 18th, at the age of four months because of an enlarged head. The patient was born by a normal, full term, spontaneous delivery after a normal pregnancy. The birth weight was 3,050 gms. She breathed and cried spontaneously, and was apparently normal until the fourteenth day. At that time there was a rapid increase in the size of the head, noticed by the parents, and the temperature rose to 39° C. The patient was hospitalized, treated with penicillin, and discharged after one month. Since the head continued to enlarge, the local physician was consulted who referred the patient to the hospital for admission. The patient was fed with Eledon and Pelargon, to which fruit juices had been added. According to the parents, she always drank well. Family history was non-contributory.

Physical examination: The general appearance was that of a 4 months old, well nourished, well developed female infant with an enlarged head, who appeared in good general condition. The patient was extremely excited, and cried loudly. The body measurements showed an overweight of 1,300 gms. and a head circumference of 51 cm. (norm. 42 cm). Body length, chest circumference, and abdominal circumference were normal. Temperature was afebrile. Skin, hair and nails were normal. Lymph nodes were not remarkable. Skeletal examination showed a large, round skull, especially the cranium, and a relatively small facial part. The large fontanel was wide, 4.5 cm., its borders thick, and the tension was increased. The vertebral column was straight. The thorax was symmetrical. No rachitic signs were present. The extremities were slender and not remarkable. The eyes showed bulbi of normal size. The sign of the setting sun was present. There was occasional slight horizontal nystagmus. The sclerae were white. The pupils were of moderate size, round, regular, and equal, and reacted promptly to light and accomodation. The fundus was not remarkable. The mouth, ears, nose and throat were not remarkable. No adenopathy was present. The thyroid was not enlarged. The lungs showed normal borders and motility, and were clear to auscultation and percussion. The heart had a normal rhythm. The tones were clear with normal accentuations, and no pathological murmurs were heard. The abdomen was soft, indolent, and no

organs were felt. The hernial orifices were closed. The central nervous system showed intact motility and sensibility. Muscle tonus was normal, and no meningitic or encephalitic signs were present. The deep tendon reflexes were active and equal, and there were no pathological reflexes.

Special Examinations: Urinalysis was negative. Blood examination showed a hemoglobin of 80 %, red cell count of 4,300,000 white cell count of 14,400 with a normal differential. The colour index was 0.94 and the sedimentation rate was 6/13/31 mm. Lumbar puncture showed a normal pressure, clear, colourless fluid. Pandy ++, Haine negative, proteins (Kafka) 192 mg.% of which 71 % was albumin, sugar 47 5 mg.%, NaCl 668 mg.%, and 60/3 cells which were mononuclears. The Wasserman was negative, and the colloidal gold and Mastix reactions gave a parenchyme type of curve. The skull x-rays showed the cranial vault enlarged and thinned, the sutures separated in the area of the coronary and lambdoidal sutures. The digital impressions were not increased, and there was a downward displacement of the skull base. No intracranial calcifications were present. The tuberculosis tests were negative. The texoplasmosis reactions were negative. The electroencephalogram was interpreted as being suggestive of a possible tumor in the left parietooccipital region or intratentorial with distant effects on both hemispheres.

Course: The patient was fed with Pelargon 17 % which was later increased to Pelargon 19 %. The patient was very restless and vomited occasionally, but she was quieted by sedation with phenobarbital suppositories. She was also given magnesium sulfate and Cibalgin. On February 2nd, a blue test was performed. Methylene blue was injected into the right lateral ventricle and at the same time a spinal tap was done. The lumbar spinal fluid appeared blue after seven minutes. A ventriculogram was done by infecting 3 cc. of air into each lateral ventricle through the large fontanel. Liquor was reached at a puncture depth of 5 mm. The films showed an extensive bilateral hydrocephalus internus with the left ventricle larger than the right. The cortex was thin bilaterally. The basal cisterns were visualized. No suggestive signs of a tumor were present. The next day an abdominal drainage operation was performed, and a drainage was created by running a polyethylene catheter from the lumbar subarachnoid space subcutaneously into the peritoneal cavity. Following the operation, the increased tension of the fontanelle was decreased and the fontanel sank inward. The post-operative course was uneventful. A urine analysis and blood examination on February 18th were normal. The patient was continued on Pelargon 19 % and phenobarbital suppositories. The fontanel appeared less tense, the child appeared quieter, and was gaining weight adequately. On February 28th, the head circumference was 55 cm. and a ventricle puncture was done. The fluid showed a normal pressure, was synthochromic, Pandy ++, protein (Kafka) 240 mg.%, sugar 27.5 mg.% and, 12/3 mononuclear cells on March 1st, the patient was drinking poorly, and 5 % Dextropur was added to the diet. It was increased to 7 % Dextropur after four days. A spinal tap on March 9th showed normal pressure, xanthochromic fluid, Pandy +++, protein (Kafka) 432 mg.%, and 8/3 cells. On March 15th, the patient appeared to be doing well, had become somewhat livelier, and was drinking somewhat better. The fontanel was soft. Two days later she was discharged on phenobarbital suppositories.

Summary of Case 1:

A four months old female infant was admitted to the Jenner Kinderspital because of an enlarged head which appeared 14 days after birth. Physical examination and skull x-rays showed enlarged fontanels with increased tension, an enlarged head circumference, an enlarged and thinned cranial vault and separation of the sutures. The electroencephalogram suggested a tumor in the left parieto-occipital region or infratentorial. A dye test and ventriculograms showed an extensive bilateral hydrocephalus internus, with no signs of a tumor. An abdominal drainage operation was performed with apparently good therapeutic results. The post-operative course was uneventful and the patient was discharged on phenobarbital suppositories.

CASE 2

The patient, J.E.A., is a 4 1/2 months old male infant admitted to the Jenner Kinderspital on February 11th because of convulsive attacks. The patient was born on September 23rd by a normal, full term, spontaneous delivery after an uneventful pregnancy. The mother was told that the child had suffered a cerebral hemorrhage. The patient did not breathe properly after birth and was given oxygen together with intensive external stimulation. The birth weight was 3,900 grams. The patient was not breast fed, but received Galactina, rice gruel and Guigoz milk, to which fruit juices and vegetables were added at one month and three months respectively. He had never presented any feeding difficulties. There had been no previous illnesses. Since December, the patient had been having small seizures in which he bent backwards, turned his eyes, and moved the arms and legs in a jerking manner. There was no vomiting, and no passage of urine or stools. The attacks were of only few seconds duration, and occurred once or twice a day. The frequency then increased progressively so that at the time of admission, they were occurring constantly throughout the entire day. The physical development appeared normal, but the infant was mentally retarded. He had not smiled, did not recognize his parents, did not play with his hands, and appeared to take no notice of the environment. The family history was non-contributory.

Physical Examination: The general appearance was that of a 4 1/2 months old male infant in good general condition, crying at the top of his voice. A very small cranium was noticeable. The body measurements showed an overweight of 960 gms., and a head circumference of 38 cm. (normal 41 cm). Body length, chest circumference, and abdominal circumference were normal. The temperature was afebrile. The skin, hair, and nails were normal. Skeletal examination showed a skull with a definite pyriform shape, a definite microcephaly, a narrow forehead, a slight dolichocephaly, and a wide mouth region. The anterior fontanel was the size of one fingertip. There was no craniotabes. The vertebral column was straight. The thorax was symmetrical. No rachitic signs were present. The extremities were not remarkable. The eyes showed normal bulbi. The sclerae were white. The pupils were round, regular, equal, and reacted to light and accomodation. The fundi were not remarkable. The mouth, ears, nose, and throat were not remarkable. No adenopathy was present. The thyroid was not enlarged. The lungs were clear

to auscultation and percussion. The heart showed no significant findings. The abdomen was normal, and no organs were felt. The hernal orifices were closed. The genitals showed a micropenis with a phimosis.

The left testis was somewhat high. The central nervous system showed intact motility and sensibility. The muscle tonus was normal. The reflexes were active and equal. No clonus or pathological reflexes were present. Occasionally, there were remarkable tremor-like movements of the lower jaw, and of the upper extremities in which the thumb was folded inwards, the fourth and fifth fingers strongly extended, and the second and third fingers semiflexed.

Special Examinations: Urinalysis was negative. Examination for phenylpyruvic acid was negative. Blood examination showed a hemoglobin of 96 %, red cell count of 4,900,000, leucocyte count of 16,400 with a normal differential. The colour index was 1.02. The serum value for calcium was 11.3 mg%, phosphorus 6.54 mg.%, and the phosphatase was normal. Lumbar puncture showed a normal pressure, clear, colourless fluid, Pandy negative, Haine normal, sugar 63.5 mg%, and 36/3 mononuclear cells. The Wasserman was negative, and the gold sol and Mastix curves were normal. The skull x-rays showed a definitely small skull. The digital impressions were not increased, and the vessel signs were normal. The fontanels and sutures were not closed. There were no intracranial calcifications, and the sella was not enlarged. The base was elevated. There was a displacement of the occipitals with a partial superimposition on the parietals. The electroencephalogram was interpreted as showing no signs of a focal hemisphere disturbance, but suggestive of a brain stem lesion, either in the nature of an injury or a ganglion dysfunction. The intelligence test showed a mental age of 3/4 months in contrast to the actual age of 5 months, giving an I.Q. of only 0.15.

Course: The child was fed with Pelargon 17 %, which was later increased to 19 % and to 21 %, and one vegetable meal per day was introduced. The patient received Redoxon and Panglandin. He was sedated with phenobarbital suppositories, which was later replaced by Neurobrandt syrup. Under this regime, the patient was calmer and cried less. Although the seizures and tremor-like movements could not be suppressed completely, they became less frequent and less severe. With the exception of occasional vomiting, the patient ate well and gained weight regularly during his hospital stay. The weight gain amounted to approximately 1,000 gms in five weeks. On March 21st, the patient was discharged on Neurobrandt syrup.

Summary of Case 2:

A 4 1/2 months old male infant was admitted to the Jenner Kinderspital because of convulsive seizures. Physical examination and skull x-rays showed a small skull with a definite microcephaly and suggestions of a hydrocephalus internus. The electroencephalogram was suggestive of a brain stem lesion, either in the nature of an injury or a ganglion dysfunction. Intelligence tests showed an I.Q. of 0.15. The patient was sedated with phenobarbital suppositories and Neurobrandt syrup and became calmer and cried less. The seizures and tremor-like movements became less frequent and less severe, and the patient gained weight regularly. He was discharged on Neurobrandt syrup.

CASE 3

The patient, H.H., is a four weeks old male infant admitted to the Jenner Kinderspital on March 2nd because of an enlarged head. The infant was born by a normal, full term, spontaneous delivery after a normal pregnancy. The birth weight was 3,300 gms. He breathed and cried spontaneously. At birth, the abnormally large size of the head was noticed by the midwife. The head then continued to enlarge and the patient was referred to the hospital. He had been breast fed for two weeks and at the time of admission was receiving 1/2 cow's milk, 1/2 Galctina and rice gruel 3 %. He drank well, had never vomited, and the stools were normal. Family history was non-contributory.

Physical Examination: The general appearance was that of a four weeks old, somewhat poorly nourished, very much neglected, dirty, male infant with an enlarged head. The body measurements showed a normal weight of 3,650 gms. and a head circumference of 44 cm (normal 36 cm). Body length, chest circumference and abdominal circumference were within normal limits. Temperature was afebrile. The neglected skin showed single, red, slightly desquamating patches on the legs and body. The skin turgor was slightly reduced. Elasticity was normal, and the fat cushion was slightly reduced. Over the cranium, the scalp was smooth and somewhat shiny. Lymph nodes were not remarkable. Skeletal examination showed a large thin cranium. The fontanels were open and pushed outward. The borders were soft and thin. The sutures were gaping. The eyes showed a moderate hydrocephalic glance. The pupils were of moderate size and reacted to light. The mouth, ears, nose, and throat were not remarkable. The lungs showed normal borders and motility, and were clear to auscultation and percussion. The heart had a normal rhythm. The tones were clear with normal accentuations, and no pathological murmurs were heard. The abdomen was somewhat below the thorax level. No organs or abnormal resistance were palpable. The central nervous system showed intact sensibility and a slight muscular hypertonus. No meningitic or encephalitic signs were present. The deep tendon reflexes were overactive to clonic, equal, and no pathological reflexes were present.

Special Examinations: Urinalysis was negative. Blood examination showed normal hemoglobin, red cell count, leucocyte count, and differential. Lumbar puncture showed a normal pressure, clear, colourless fluid. Pandy +. Haine normal, quantitative sugar 46,5 mg.%, Kafka for proteins 72 mg.%, 40/3 cells which were mononuclears. The Wasserman was negative, and the Mastix and Gold-sol reactions were normal. The skull x-rays showed a greatly enlarged cranium with a thin corticalis, partially uncalcified. The fontanelles were open and gaping. The sutures were separated. The sella was flat. The toxoplasmosis reactions were negative.

Course: The patient was fed with 5 % rice gruel and 5 % sugared condensed milk. A lumbar puncture on March 15th showed the same findings as previously with 15/3 mononuclear cells and Pandy +. The general condition was good and the patient was quiet on phenobarb. suppositories. The infant gained weight regularly. On March 23rd, the head circumference had increased to 45.5 cm. The fontanals

were 6.5 cm x 6.5 cm, pushed outward and of cushion-like consistency. The sutures were separated 1 cm. The patient was quiet, smiled and appeared psychically normal. A lumbar puncture showed normal pressure, Queckenstedt normal, Pandy + and 24/3 cells. Because of continuing increase in size of the head, the child was given Piton powder and magnesium sulfate. The patient appeared to be doing well, but the head continued to increase in size. On March 29th the circumference was 46 cm, and on April 4th it was 47 cm. Repeated lumbar punctures with removal of 15-20 ccm of liquor were without effect. A ventriculogram showed brain cortex of only a few mm. The dye test showed a non-communicating hydrocephalus internus. A ventriculocysternostomie on the anterior wall of the third ventricle was done with unsatisfactory results. After a short time, the fontanelles was tensed again and the head increased in size. A second operation was performed, in which a drainage of the dural sack into the peritoneum was done at the level of the lumbar vertebral column by means of a fine polyethylene catheter. The patient tolerated the operation well, and on June 19th the fontanel was still relaxed and the patient was developing well.

Summary of Case 3:

A four weeks old male infant was admitted to the Jenner Kinderspital because of an enlarged head present from the time of birth. Physical examinations and skull x-rays showed an enlarged cranium with gaping fontanels and separated sutures. A ventriculogram and dye test showed a brain cortex of only a few millimeters and a non-communicating internal hydrocephalus. A ventriculocyternostomie was done with unsatisfactory results, and a second operation was performed in which a drainage of the dural sack into the peritoneal cavity was created. Post-operatively the fontanel remained relaxed and the child was developing well.

CASE 4

The patient, M.T.B., is a female infant admitted to the Jenner Kinderspital on February 18th at the age of 5 1/2 months because of convulsive seizures and an enlarged head. The patient was born by a normal, full term, spontaneous delivery after a normal pregnancy. During the birth, the mother suffered an epileptic seizure which did not affect the course of the birth. The birth weight was 4,000 gms. She breathed and cried spontaneously. At the time of birth the parents noticed an unusually large head. No other abnormalities were noticed until the age of 4 1/2 months when the infant suffered a convulsive seizure. There was a tremor of the entire body, especially of the right hand. The patient lost consciousness, became pale, and breathed very rapidly. The tremor was followed by a strong contraction of the entire body. The attack lasted approximately one minute. After the first attack, the infant ceased moving her right arm. Since then, the patient had been having similar seizures continually, sometimes three or four consecutively, and approximately two to ten per day. The local physician was consulted, who referred the infant to the hospital for admission. The patient had been fed with Guigoz milk with rice gruel to which vegetables were added. According to the parents, she drank well and the weight gain was normal. Family history revealed that the mother suffered from epileptic seizures but was otherwise non-contributory.

Physical Examination: The general appearance was that of a 5 1/2 months old, well nourished female infant with a hydrocephalus in fair general condition. There was a noticeable nystagmus, inability to fix the eyes, and an appearance of debility. The body measurements showed an underweight of 1,100 gms., a head circumference of 47 cm (normal 42 cm) and a body length of 61 cm (normal 66 cm). Temperature was afebrile. Skin showed no abnormalities. Lymph nodes were not remarkable. Skeletal examination showed a large, strongly hydrocephalic, heavy skull. The large fontanel was approximately 1 1/2 cm. by 1 1/2 cm. No craniotabes was present. The sutures were palpable. The legs showed a strong adductor spasm. The vertebral column was straight and showed no abnormalities. The eyes showed a horizontal nystagmus to the left. The palpebral fissure was of normal width. The sclerae were white. The pupils were of moderate size, round, regular, equal, and reacted promptly to light. Fundus examination showed the papilla not sharp, somewhat pale, and not prominent. The veins were congested. The mouth, ears, nose, and throat were not remarkable. The thyroid was not enlarged. The lungs showed normal borders and motility, and were clear to auscultation and percussion. The heart had a normal rhythm. The tones were clear with normal accentuations. The pulse frequency was 100/minute and regular. No murmurs were heard. Abdomen was normal. No hernias were present.

The central nervous system showed bilaterally intact patellar reflexes, but the achilles reflexes were absent. The sensibility was intact. No meningitic signs were present, and no pathological reflexes were present. The extremities were slightly spastic on movement. The musculature was well developed. The psychic impression was one of debility.

Special Examinations: Urinalysis was negative. Blood hemoglobin, red cell count, white cell count and differential were normal. Blood chemistry determinations revealed: Urea 69 mg.%, Non-protein nitrogen 38 mg.%, total proteins 5.9 %, serum-albumin 3.48 %, serum globulin 2.42 %, A/G ratio 1.40, potassium 21 mg.%, calcium 8.75 mg.%, sodium 355 mg.%, inorganic phosphorus 4.38 mg.%, alhaline phosphotase 3.5 units.

Lumbar puncture showed a normal pressure, clear, colourless fluid, Pandy -, with normal sugar, protein, and cells. The colloidal cold and Mastix curves were normal. The Wasserman was negative. The skull x-rays showed a macrocephalie, and no intracranial calcifications. The toxoplasmosis reactions were negative. The electroencephalogram showed a definite assymetry, in which there was a strongly pathological activity over the entire left hemisphere, while in the right side there was a frequency spectrum which corresponded to the age of the patient. The generalized, continual paroxysms indicate a general seizure predisposition and seizure activity in the degeneratively changed brain. The encephalogram showed a greatly enlarged right lateral ventricle, an enlargement of the basal cisterns, and a normal fourth ventricle. It was interpreted as indicative of a malformation with an extensive left-sided hemisphere shrinkage and an extensive right-sided hydrocephalus internus with probable obliteration of the subarachnoid space.

Course: The patient was fed with Pelargon 17 %, which was later increased to 19 % and 21 %.

On March 3rd, a fever of undetermined origin appeared and the patient was given Terramycin and Gantrisin. A lumbar puncture and urinalysis at this time were normal. All investigations concerning the nature of the fever were negative. On March 16th, after the fever failed to respond in spite of therapy with Gantrisin, penicillin, Terramycin, and Irgapyrin, all previous medicaments were replaced by 1.5 % Pyramidon. The Pyramidon was continued, and on April 6th, the fever returned to normal. The patient did not have any seizures during her stay in the hospital. Because of the severe brain malformation shown by the encephalogram, operative intervention was considered useless. On April 8th, the patient was discharged.

Summary of Case 4:

A 5 1/2 months old female infant was admitted to the Jenner Kinderspital because of an enlarged head and convulsive seizures. Physical examination and skull x-rays showed an enlarged head circumference and a nystagmus. The electroencephalogram showed pathological activity over the left hemisphere of a paroxysmal nature causing a general seizure predisposition and seizure activity. Encephalograms showed a left-sided hemisphere shrinkage and an extensive right-sided hydrocephalus internus. No seizures occurred while the patient was in the hospital. Operation was considered useless because of the severe brain malformation, and the patient was discharged.

CASE 5

The patient, F.K., is a 28 months old female infant admitted to the Jenner Kinderspital on December 4th because of attacks of vomiting, muscle flaccidity, and cyanosis following a skull injury. The patient was delivered by Caesarian section at term because of absence of labor. The birth weight was 3,350 gms. She breathed and cried spontaneously and no asphyxia was present. She smiled at 4-6 weeks, fixed at 2 months, the first teeth appeared at 11 months. She sat up at 10 months, stood at 16 months, walked at 20 months, and began to speak at 16 months. With the exception of a light grippe a year ago, she had never been ill. At birth no enlargement of the head was noticed by the parents, but during the next few months, they noticed that the head was growing very rapidly. At the age of 22 months, during lunch, the patient suffered a sudden seizure. She became quiet, turned her eyes, gnashed her teeth, breathing stopped, and the child became blue. She did not react to anything, and there was a questionable period of unconsciousness of one to two minutes duration. The patient was completely flaccid during the attack and vomited after recovering. A similar seizure occurred again the same afternoon, but the patient was free from such attacks until the October before admission. On October 7th, the patient fell backwards out of her chair and struck the floor with the back of her head. She did not lose consciousness, did not cry, was frightened, but did not vomit. A physician was consulted who diagnosed a hematom over the right portion of the occiput. There were no wounds, but x-ray films revealed a fissure of the cranial vault. The patient was treated with a sedative. Five weeks later the patient became apathetic, pale, slightly cyanotic

and vomited. On the day of admission she suffered two similar seizures in which she became flaccid, turned her eyes, did not react, became cyanotic and vomited. The patient was breast fed for 7 weeks and then given Guigoz milk and rice gruel to which vegetable and fruit juices were added. Family history was non-contributory.

Physical Examination: General appearance was that of an extremely excited child, crying continually, with a noticeably large head, clear sensorium, good general condition and slightly reduced nutritional condition. Body measurements showed an underweight of 1,200 gms. and a head circumference of 56.5 cm (normal 48 cm). Body length, chest circumference, and abdominal circumference were normal. Temperature was afebrile. Skin, hair and nails were normal. Lymph nodes were not remarkable. Skeletal examination showed a large head, closed fontanels, and no suture separations palpable. No external signs of skull fracture, hematom, or injuries. No rachitic signs. No other skeletal abnormalities present.

The eyes showed bulbi of normal size, no nystagmus, no strabismus, sclerae white, conjunctivae clear. Pupils were of moderate size, round, regular, equal, and reacted to light. A healing hordeolum was present on the left lower lid. The fundus was normal. The mouth, ears and nose were not remarkable. The tonsils were enlarged and reddened, with no coating or plugs. Thyroid was not enlarged. The lungs were clear to auscultation and percussion. The heart had a normal rhythm. The tones were clear with normal accentuations, and no pathological murmurs Pulse was 140 regular. The abdomen was soft, indolent and no organs were felt. No hernias. The nervous system showed intact sensibility and motility. No nystagmus. Sensorium was clear with motor restlessness. No meningitic signs. Arm reflexes poorly elicited bilaterally. Abdominal reflexes absent. Right patellar reflex hyperactive with increased reflex zone. Left patellar reflex active but normal. Right Achilles reflex clonic, left normal. Babinski, Gordon, Oppenheim slightly positive right, negative left. Patient speaks clearly. Affective rapport gut.

Special examinations: Urinalysis was negative. Blood examination showed a hemoglobin of 104%, red cell count of 5.1 million, leucocyte count of 6,200 with a normal differential. Lumbar puncture showed a strongly elevated pressure, clear, colourless fluid. Pandy -, sugar 69.5 mg.%, and 2/3 cells. 30 cc. of liquor were removed. The Mastix and colloidal gold curves were normal and Wasserman was negative. The skull x-rays showed a marked hydrocephalic, enlarged cranium with a thinned vault, and no demonstrable suture separations. In the right occipito-parietal region was a horizontal fissure. No intracranial calcifications were present. The skull base and sella turcica were not remarkable. The intelligence tests showed a developmental age of 23 months, with an actual age of 28 months, and I.Q. of 0.8.

Course: The patient was treated with Elkosin, Penicillin, Anthiphlogistin neck bandages and Calcium bromate-phenobarbital. On December 7th, the tonsillitis had healed but the patient was still restless. Further sedation with Luminal was given without effect. On December 9th, following lumbar puncture, the child was much quieter, did not cry, ate well. No attacks had occurred since hospital admission.

On December 16th, the child was lively, alert, spoke, and appeared to be doing well. A blood examination on Dec. 19th showed haemoglobin 88 %, leucocyte count 3,400 with a normal differential. A lumbar puncture showed a pressure of 140 mm H_2O, clear colourless fluid, 9/3 cells, sugar 60 mg.%. On January 7th, a pneumoencephalogram under narcosis was done which showed a normal liquor pressure with an enormous hydrocephalus internus communicans. There were no signs of a stenotic process causing hindrance of liquor flow. Further surgical intervention at this time was considered contraindicated and the child was discharged under further observation.

Summary of Case 5:

A 28 months old female infant was admitted to the Jenner Kinderspital because of attacks of vomiting, muscle flaccidity, and cyanosis following a skull injury. Physical examination and skull x-rays showed an enlarged head with a markedly enlarged cranium, a thinned vault, no suture separations and a horizontal fissure in the right occipito-parietal region. The I.Q. was 0.8. A pneumoencephalogram showed an enormous hydrocephalus internus communicans. Surgical intervention was considered contraindicated at the time. The patient was sedated with Calcium bromate-phenobarbitol and Luminal and discharged under further observation.

CASE 6

The patient, I.B., is a 9 months old female infant admitted to the Jenner Kinderspital on September 6th because of an enlarged head. The patient, the second of twins, was born four hours after the first child. The birth was extended in duration because of weak labor and a version was necessary because of a transverse position. The birth weight was 2,300 gms. The patient breathed and cried spontaenously. At the age of 3 months, the parents noticed a misproportion between the head and body. The head continued to enlarge and the patient was brought to the hospital for admission. A strabismus was noticed at the time of birth. Family history was non-contributory.

Physical examination: The general appearance was that of a 9 months old, well nourished female infant with an enlarged frontal portion of the skull and apparent hydrocephalus who appeared in good general condition. There was no dyspnea, no cyanosis, no coughing. Consciousness was clear. The body measurements showed an underweight of 1,100 gms. and a head circumference of 47 cm (normal 43 cm). Body length, chest circumference and abdominal circumference were normal. No lymph nodes were palpable. Skeletal examination showed the large fontanel open, 4 x 4 cm. The frontal portion of the skull was pushed forward and the parietal bones laterally were somewhat arched outward. The occiput descended steeply. There was no craniotabes. The thorax was symmetrical with no pathological deformities and a slight rachitic rosary. The vertebral column and extremities were movable and not remarkable. The eyes showed a slight strabismus, due to bilateral abducens paresis, and no nystagmus. Pupils reacted to light. Sclerae were slightly blue. Fundus was normal. The mouth, ears, nose and throat were

not remarkable. Thyroid was not enlarged. Lungs showed normal borders and motility, and were clear to auscultation and percussion. The heart had a normal rhythm, clear tones with normal accentuations, and no pathological murmurs. The abdomen was below thorax level, soft, indolent, and no organs were palpable. No hernias present. The central nervous system showed intact motility and sensibility. Muscle tonus was slightly decreased. No menigeal signs were present. The deep tendon reflexeswere active and equal and no pathological reflexes were present. The hands and feet were slightly blue and cold.

Speical Examinations: Urinalysis showed a large number of leucocytes with no other positive findungs: Blood examination showed a hemoglobin of 65 %, red cell count of 4.1 million, white cell count of 12,000 with a normal differential, and colour index of 0.8. Lumbar puncture showed normal pressure, clear, colourless fluid. Pandy equivocally (+). Nonne -, Haine -, 9/3 cells, sugar 43.0 mg.%. The Wasserman was negative and the colloidal gold and Mastix reactions gave a normal curve. A ventricle puncture showed normal pressure, clear, colourless, fluid, Pandy equivocal, Nonne -, Haine -, 3/3 cells. The skull x-rays showed an extensive enlargement of the cranium. The skull base was pressed downward. The dorsum sellae was diminished in size and the sutures were gaping. The vault was very thin.

Course: The patient was fed with 2/3 Citrettenmilk, 2 % Soldor, 5 % Nutromalt, Paidol bouillon with fruit and vegetables. She was given Ferro-iron for the anemia, and sedated with Phenobarbital suppositories.

The patient was transferred to the Neurosurgical Division where a fontanelle puncture was done in which the ventricle was reached at a depth of 1 1/2 cm. The liquor was cloudy and contained leucocytes and streptococcus lactis. Under penicillin the liquor became sterile. The x-ray films showed a large hydrocephalus internus with the stenosis most likely in the region of the posterior cranial fossa. On September 30th, a ventriculocisternostomie was done by opening the lamina terminals of the third ventricle. The post-operative course was at first without complication, but during the night of December 2nd, the patient suddenly died. Postmortem examination revealed a tumor in the fourth ventricle which blocked the liquor passage.

Summary of Case 6:

A 9 months old female infant was admitted to the Jenner Kinderspital because of an enlarged head. Physical examination and skull x-rays showed an enlarged head circumference due to extensive cranial enlargement, gaping sutures, and a very thin vault. Ventriculograms showed a large hydrocephalus internus with a stenosis most likely in the area of the posterior cranial fossa. A ventriculosisternostomie was done, but the patient expired suddenly two days after the operation. Postmortem examination revealed a tumor in the fourth ventricle blocking the fluid passage.

CASE 7

The patient, R.F., is a 4 1/2 months old male infant admitted to the Jenner Kinder-spital on March 9th because of muscular contractions. The patient was born by a normal, full term, spontaneous delivery after a normal pregnancy. The birth weight was 3.000 gms. He breathed and cried spontaneously and there was no icterus or asphyxia at birth. From the third to the fourteenth day the patient was icteric, but blood examinations for Rh incompatibility were negative. During this period he was also asphyctic, but he improved after ten days. In December, the infant began to have muscular contractions in both arms and legs. These were of short duration, only in the extremities, and the sensorium remained clear. The interval between attacks was at first 14 days, but they increased in frequency and prior to admission they were occurring almost daily. During the attacks the child remained cheerful and appeared to show no pain. The patient was fed with Citrettenmilk, Pelargon, a carrot preparation, and fruit juices. He drank well and gained weight regularly. The family history was non-contributory.

Physical Examination: The general appearance was that of a 4 1/2 month old, well nourished male infant in good general condition, crying, but showing no contractions. The body measurements showed a body weight of 6.050 kg. (normal 6,3 kg) and a head circumference of 38,5 cm (normal 43 cm). Body length, chest circumference and abdominal circumference were normal. Temperature was afebrile. The skin and hair were normal. The nail on the right thumb was absent, but the others were normal. No lymph nodes were palpable. Skeletal examination showed a microcephalic skull, globular, and configurated. The right parietal bone was pushed outward and was above the level of the flatter left parietal at the sagittal suture which was displaced slightly to the right. The fontanel was open, the size of one fingertip, soft, not protruding. No craniotabes was present. The thorax was symmetrical. No rachitic rosary was present. The extremities were normal. The eyes showed normal motility of the bulbi, but there was a failure to fix objects and to react properly to optical stimulation. The conjunctivae and sclerae were clear. The pupils were of moderate size, round, regular, equal, and reacted to light. Fundus examination was normal. The mouth, ears, nose and throat were not remarkable. The thyroid was not enlarged. The lungs were clear to auscultation and percussion. The heart had a normal rhythm. Clear tones with normal accentuations and no pathological murmurs were heard. The abdomen was soft and indolent. The liver was felt about 1/2 finger below the rib margin. The spleen was not palpable. No hernias were present. The genitals showed a slight phimosis. The central nervous system showed a clear sensorium and intact motility and sensibility. Muscle tonus was slightly increased. No meningitis signs were present. The deep tendon reflexes were active and equal, the abdominal reflexes were absent, and there were no pathological reflexes.

Special Examinations: Urinalysis was negative. Blood examination showed a hemoglobin of 79 %, red cell count of 4.000.000, white cell count of 6,100 with a normal differential, and a colour index of 0.98.

Lumbar puncture showed a normal pressure, clear, colourless fluid, Pandy slightly +, Nonne -, sugar 52.5 mg.%, 24/3 cells which were lymphocytes and fresh erythrocytes. The spinal fluid Wasserman was negative. The skull x-ray showed the cranium and sutures to be normal for the corresponding age. There was no signs of intracranial calcifications.

Course: The patient was fed with Pelargon 16 %. He was sedated with Calcium bromate-phenobarbital. On March 12th, the patient was showing, two to four times daily, extensive contractions of the entire body. There was an extensor cramp of short duration with frequent fine tremors of the eyelids and lower lip. The child was fixing poorly and did not follow objects with his eyes. Mesantoin in increasing dosages from 1 x 1/4 tablet to 6 x 1/4 tablet per day together with Calcium bromate-phenobarbital failed to control the continuing contractions. On April 15th, the Mesantoin was replaced by Sanalepsi with better effect, so that on April 22nd, the contractions had diminished in frequency. An x-ray film of the thorax showed a probably thymus hyperplasia with displacement of the trachea posteriorly. On April 28th, the patient was operated under ether narcosis. From a left parietal scalp incision the bone was exposed and trepanated. The dura was normal. The arachnoid was brownish and thickened. Upon opening the arachnoid, clear liquor flowed out, the brain appeared at a depth of 1 cm and was separated from the dura. The diagnosis was hydrocephalus externus with microcephalus, probably due to an old subdural hematom. After operation, the patient was placed on Sanalepsi and Calcium bromate-phenobarbital and then on the latter alone. The post-operative course was uneventful, and the attacks disappeared completely. The patient gained weight regularly. However, the patient still failed to fix objects and to react to optical stimulation although the pupils reaction was normal. The intelligence test showed a mental age of 3 months, and the patient failed to grasp objects. On June 6th, the patient was discharged in good general condition on Calcium bromate-phenobarbital. The head circumference was 40 cm which was still microcephalic.

Summary of Case 7:

A 4 1/2 months old male infant was admitted to the Jenner Kinderspital because of attacks of muscular contractions. Physical examination and skull x-rays showed an abnormally small skull with normal sutures, and an inability to fix objects, or to react to optical stimulation. Following failure to control the attacks medicinally, operation was performed which revealed a hydrocephalus externus with microcephalus, probably due to an old subdural haematom. The attacks disappeared after operation, but the inability to fix objects and to react to optical stimulation remained. An intelligence test showed a mental age of 3 months. The patient was discharged in good general condition but the skull was still of microcephalic proportions.

CASE 8

The patient, Y.G., is a 26 months old female child admitted to the Jenner Kinderspital on November 4th for observation. The patient was born by a normal,

full term, spontaneous delivery after a normal pregnancy. The birth weight was 2,750 gms. She was bluish-red at birth and breathed and cried only after slapping and aspiration of mucous. Until the age of 3 months the patient did not cry properly. For the first 2 months after birth, the patient suffered from convulsive seizures once or twice daily in which she did not breathe. She did not lose consciousness, did not turn her eyes or foam at the mouth. After 2 months the seizures disappeared spontaneously. Since the age of one year, the patient had been having frequent anginas. She had had no infectious diseases or other illnesses. The patient sat at one year, stood at 18 months and walked at 23 months. Aside from poor physical growth, no other developmental abnormalities were noticed. The patient was breast fed for 3 1/2 months and then fed with rice gruel, vegetables, and fruit juices. She supposedly ate well. Family history was non-contributory.

Physical Examination: The general appearance was that of a poorly developed 26 months old female child who appeared in good general condition. She was somewhat excited and restless and had a deviation of both eyes. The small head was especially noticeable. The body measurements showed an underweight of 2.1 kg, a head circumference of 44 cm (normal 48 cm), a body length of 82 cm (normal 85 cm). Chest and abdominal circumferences were normal. Temperature was afebrile. Skin, hair, and nails were normal. No lymph nodes were palpable.

Skeletal examination showed a slender build, no deformities, and a small skull of ovoid form. The large fontanel was closed. The eyes showed a bilateral strabismus convergens. The pupils were of moderate size, round, regular, and equal, and reacted to light. The fundus was normal. The mouth, ears, nose, and thoat were not remarkable. The thyroid was not enlarged. The lungs were clear to auscultation and percussion. The heart had a normal rhythm. Pulse rate was 132, regular. The tones were clear with normal accentuations, and no murmurs were heard. The abdomen was soft, indolent, and no organs were felt. Genitals were not remarkable. The central nervous system showed intact motility and sensibility. No meningitic signs. The deep tendon reflexes were hypoactive, but equal. Abdominal reflex was positive, and Babinski was negative. The gait was somewhat uncertain and broad based. By rapid movement there was stumbling and a tendency to fall forward.

Special Examinations: Urinalysis was negative. Blood examination showed a hemoglobin of 82 %, red cell count of 4 million, leucocyte count of 6,800 with a normal differential, colour index 1.05, sedimentation rate 2/4/6 mm. Lumbar puncture showed a pressure of 180-200 mm, clear, colourless fluid, Pandy -, 2/3 cells, sugar 48 mg.%, chlorides 492 mg.%, Kafka 24 mg.%. The fluid Wasserman was negative and the colloidal Gold and Mastix reactions gave normal curves. The skull x-rays showed a normal form of the cranium. There was a pathological increase of the digital impressions, and the coronary and sagittal sutures were somewhat widened. The sella was below normal size, but the clinoid processes were intact. The clinical diagnosis was microcephalus with a slight hydrocephalus internus. X-rays of the hands showed normal development and no signs of rickets.

An intelligence test showed a developmental age of 2 years with a normal I.Q. of 1.0. The Moro and Pirquet tests were negative.

Course: The patient was fed with a normal diet and given glutamic acid, Benadon, Magnesium sulfate. During the hospital stay the child was lively and cheerful, played well with the other children and showed good affective rapport. When attempting to run, the atactic gait became apparent, and she would stagger sidewards and often fall forward. She was able to stand up immediately after falling and dit not cry. During the hospital stay there was a weight gain of 400 gms. The child was discharged on November 19th on a regime of glutamic acid, Benadon and small doses of Magnesium sulfate under further observation.

Summary of Case 8:

A 26 months old child was admitted to the Jenner Kinderspital for observation. Physical examination and x-rays showed an abnormally small head, a pathological increase of the digital impressions and a widening of the coronary and sagittal sutures. An intelligence test showed a normal I.Q. of 1.0. An atactic gait became apparent when the child attempted to run. The child was given glutamic acid, Benadon and Magnesium sulfate during her hospital stay. The clinical diagnosis was microcephalus with a slight internal hydrocephalus and the patient was discharged on the same therapeutic regime under further observation.

CASE 9

The patient, W.B., is a 21 months old male infant admitted to the Jenner Kinderspital on December 21st because of sudden lethargy and inability to stand. The patient was born by a normal, full term, spontaneous delivery after a normal pregnancy. The birth weight was 3,400 gms. He breathed and cried spontaneously, and there were no signs of asphyxia. The patient had never been ill previously. Two days prior to admission the child appeared "changed", was restless, but did not complain of definite pains. He was unable to sleep at night and gave a generally sick impression. The stools were normal. A physician was consulted who found nothing. Urine examination was normal. On the day of admission, the patient was unable to sit up or stand and became progressively worse until he lay on his side in bed in an opisthotonus position. There was no vomiting, no headache, and no fever. A few days before admission the patient fell at home from an oven on his head. The previous development had been normal. The first teeth appeared at five months, he sat at 8 months, stood at 10 months, walked at 14 months and began to speak at 20 months. The patient was fed with breast milk for 6 weeks and then given Guigoz milk, Paidol, fruits and vegetables. He always ate and drank well. Family history was non-contributory.

Physical Examination: The general appearance was that of a 21 months old, well nourished, well developed, male child, who appeared acutely ill. He lay in bed with the legs flexed in an opisthotenus position. Upon sitting him up passively, he remained sitting though somewhat uncertain. The face was deeply erythematous

in contrast to the rest of the body. There was no exanthema. The head appeared somewhat large and the thorax showed slight rachitic changes. Consciousness was intact. The body measurements showed a body weight of 11 8 kg (normal 11.8 kg), head circumference of 49 cm (normal 50 cm), body length of 81 cm (normal 84 cm), chest and abdominal circumference were normal. Temperature was afebrile. The hair and nails were normal. No lymph nodes were palpable. The eyes showed normal bulbi. The conjunctivae and sclerae were clear. The pupils were of moderate size, round, regular, equal and reacted to light. Fundus examination was normal. The nose, mouth, ears, and throat were not remarkable. The lungs showed a somewhat hyperresonant percussion tone with very soft vesicular breathing. No rales were present. The heart had a normal rhythm, clear tones with normal accentuations, and no murmurs. The abdomen was soft, indolent, and no organs were felt. The central nervous system showed a weakly positive head drop, moderate but clearly positive neck stiffness, positive Kernig and positive Lasegue. A slight hyperaesthesia was present. The patellar reflexes were normal, but the Achilles and abdominal reflexes could not be evaluated because of resistance.

Special Examinations: Urinalysis was negative. Blood examination showed hemoglobin 75 %, erythrocyte count 3.8 million, leucocyte count 7,400 with a normal differential and colour index 0.98. Lumbar puncture showed pressure strongly elevated, slightly cloudy to clear fluid, Pandy very weakly positive, Nonne negative, Haine normal, 10/3 mononuclear cells and 60/3 erythrocytes. Thorax flouroscopy showed no pathological findings. Skull x-rays showed a large, asymmetrical skull especially in the area of the anterior cranial fossa. The sutures were not separated. There was a moderate increase in the digital impressions, and the cranial vault was thinned in the frontal area. A hydrocephalus was considered probable. An intelligence test showed a developmental age of 22 months at an actual age of 22 months for an I.Q. of 1.0. A tuberculin test was negative.

Course: The patient was given Irgapyrin which was replaced after a week by Calcium bromate-phenobarbital. He also received Redoxon and Bonadon. A lumbar puncture on December 22nd showed low to normal pressure, clear fluid, Pandy slightly positive, Haine normal, 77/3 cells and red blood cell shadows. No neurological disturbances were found at this time. On December 27th, the patient was showing only occasional restlessness and a lumbar puncture showed low pressure, clear fluid, no xanthochromia, Pandy negative, Haine normal, and 1600/3 red blood cell shadows, and a few leucocytes with no phagocytosis of erythrocytes. A puncture the following day showed 400/3 red cell shadows, but was otherwise unchanged. Urinalysis on December 31st was normal. On January 3rd, a lumbar puncture showed normal pressure, clear colourless fluid, negative Pandy, Haine normal, 3/3 lymphocytes, no blood shadows. The patient was much calmer psychically. On January 9th, the patient was standing up, walking about with no difficulty, muscle tonus was good, reflexes were normal, Babinski was negative, no neck stiffness or head drop were present. He was cheerful, reacted normal, ate well, and was discharged from the hospital with a clinical diagnosis of acute hydrocephalus possibly due to trauma.

Summary of Case 9:

A 21 months old male infant was admitted to the Jenner Kinderspital because of an acute onset of lethargy, weakness, inability to stand and opisthotonus following a head trauma. Physical examination showed an acutely ill patient in opisthotonus position with a weakly positive head drop, neck stiffness and positive Lasegue and Kernig. An initial lumbar puncture showed elevated pressure and numerous red blood cells, but subsequent punctures showed normal pressure with numerous red cells and no xanthochromia. Skull x-rays showed a large asymmetrical skull with a moderate increase in the digital impressions and a thinning of the cranial vault. The I.Q. was normal. The patient was given Irgapyrin, Calcium bromate-phenobarbital, Redoxon and Benadon, and after repeated lumbar punctures the fluid cleared, physical signs disappeared, and the patient reacted normally. He was discharged with a clinical diagnosis of acute hydrocephalus, possibly due to head trauma.

CASE 10

The patient, C.G., is a female infant admitted to the Jenner Kinderspital at the age of 2 months because of a large head. The patient was born by a normal, full term, spontaneous delivery after a normal pregnancy. The birth weight was 3,400 gms. She breathed and cried spontaneously and the head was of normal size at birth. On the third day, the parents noticed that the head began to enlarge rapidly and that the enlargement became progressively worse until the time of admission. The patient was fed with condensed milk and Galactina. Family history was non-contributory.

Physical Examination: The general appearance was that of a 2 months old, well nourished female infant in moderate general condition, with a very large head. The patient was quiet and cried only seldom. The body measurements showed a body weight of 4,030 gms. (normal 4,200 gms), a head circumference of 46.0 cm (normal 36.0 cm), body length of 54.0 cm (normal 56.0 cm), thorax circumference of 34.0 cm (normal 36.0 cm) and an abdominal circumference of 32.0 cm. Temperature was afebrile. Skin, hair, and nails were normal. No lymph nodes were palpable. Skeletal examination showed an enlarged skull. The fontanels were large and open. The thorax was symmetrical. The extremities were not remarkable. The eyes showed bulbi of normal size. The conjunctivae and sclerae were clear. The pupils were of moderate size, round, regular, equal, and reacted to light. The fundus showed slightly congested veins but was otherwise normal. The mouth, ears, nose, and throat were not remarkable. Thyroid was not enlarged. The lungs showed normal borders and motility and were clear to auscultation and percussion. The heart had a normal rhythm. The tones were clear with normal accentuations, and no murmurs were heard. Pulse rate was 96, regular. The abdomen was soft, indolent, and no organs were felt. No hernias were present. The central nervous system showed intact sensibility and motility. Muscle tonus was normal, and no meningitic or encephalitic signs were present. The deep tendon reflexes were active and equal, and there were no pathological reflexes.

Special Examinations: Urinalysis was negative. Blood examination showed hemoglobin 71 %, red blood cells 3.5 million, colour index 1.02, leucocytes 11,400 with a normal differential. Lumbar puncture showed normal pressure, clear colourless fluid, Pandy ++, Nonne -, Haine normal, 3/3 cells. Wasserman negative. Skull x-rays showed a general diffuse, milky opacity. A small, flat sella was present. Encephalography gave the picture of a sphere filled with water and air, and showed an enormous hydrocephalus. Toxoplasmosis reactions were negative.

Course: The patient was fed with 10 % condensed milk and 5 % rice gruel. On February 5th, under narcosis, an operation was performed in which a small right-sided, frontal skin flap was lifted. Underneath, the bone was paperthin. The skull and dura were incised, and a great deal of fluid flowed out, after which the cranial cavity was practically empty. The brain was represented only by a small nodular structure 6 x 3 x 3 cm in size. The condition was one of almost an anencephalic with an enormous hydrocephalus externus, and under these circumstances the operation was discontinued. After operation, the patient was fed with condensed milk 10-20 % and rice gruel 5 %, Paidol bouillon, 2/3 Citrettenmilk, 2 % Soldor, 5 % Dextropur to which bananas and vegetable purée were later added. She was sedated with Phenobarbitol and Cibalgin suppositories. An intercurrent purulent otitis media was treated successfully with Trisulfanylsyrup. To relieve increased pressure, repeated ventricular punctures were done at intervals of 3-5 days with 50-120 cc of fluid being removed each time. The fluid was continually xanthrochromic and had an increased protein content. In spite of the condition found at operation, the infant continued to live until October. After the fontanel punctures the liquor leaked for a time through the puncture canal, so that on October 1st, after a deteroration of the general condition and a temperature rise to 39° C, Staphylococci were found in the liquor. Penicillin was given without effect and exitus occurred on October 3rd.

Postmortem examination showed: skull circumference 52 cm, skull bones very thin. Only a strongly compressed portion of both occipital lobes remained of the cerebrum. In the other areas was found only thickened, opaque meninges, covered on the inner side with yellow membranes. Macroscopically almost no brain substance was demonstrable. The mesencephalon, pons, and cerebellum were normal in size. The third ventricle and aqueduct were narrowed, the fourth ventricle was of normal size. The tela chorioidea was well developed. The hypophysis was normal in size. The other organs showed no significant pathological changes.

Summary of Case 10:

A 2 months old female infant was admitted to the Jenner Kinderspital because of an enlarged head which appeared at the age of 3 days. Physical examination, skull x-rays, and encephalography revealed an enormously enlarged head which gave a picture of a sphere filled with water and air. Operation revealed an almost, anencephalic condition, with the brain being represented only by a small nodular structure 6 x 3 x 3 cm in size, and an enormous hydrocephalus externus. The operation was discontinued and symptomatic relief by repeated ventricular punctures was provided for a period of eight months until the patient died of a staphylococcal

infection of the cerebrospinal fluid. Postmortem examination showed thin skull bones, only a small portion of the occipital lobes remaining of the cerebrum, thickened, opaque meninges, normal size mesencephalon, pons, and cerebellum, and narrowed third ventricle and aqueduct.

SUMMARY

Hydrocephalus is a general term referring to an excessive accumulation of fluid within the intracial cavity. It may be due to a number of causes, takes many forms, and has various clinical manifestations. It may cause an excessive enlargement of the head, the head may retain its normal size, or it may even be diminished in size. The latter form has been called hydromicrocephaly. The various forms of hydrocephalus have been classified as follows: congenital and acquired hydrocephalus, primary, essential, or idiopathic hydrocephalus, external and internal hydrocephalus ex vacuo, and hydrocephalus occultus. The microcephalic forms have been classified into microcephalia vera and pseudomicrocephaly. A consideration of the cerebrospinal fluid, its production, circulation, and resorption reveals how numerous disturbances at different locations in the system will cause an abnormal fluid accumulation with varying manifestations. The disturbances may be of an infectious, neoplastic, hemorrhagic, or developmental nature. The familial incidence suggests that endogenous factors may also play a role. The common pathological change in all forms, regardless of the cause, is the increased amount of fluid, usually at the expense of the brain substance. In internal hydrocephalus there is ventricular dilatation. The typical clinical picture with the pronounced head deformity of either the enlarged form or the microcephalic form is unmistakable. The changes occur primarily in the cranial vault which is either increased or diminished in size. The facial portion of the skull usually remains normal, and it is the discrepancy between the two skull portions which usually produces the characteristic appearance. There are usually other nervous symptoms present. The fontanelles and cranial sutures usually show characteristic changes. All forms are usually accompanied by mental deficiency of varying severity. The chief diagnostic procedure is roentgenographic contrast visualization of the ventricles by either the encephalogram or the ventriculogram. The contrast films give exact information concerning the presence, extent, and form of the ventricular dilatation. Dye studies are also useful. Ventriculograms and dye studies may be done together as part of a general intracranial diagnostic puncture. The prognosis is generally poor with most cases dying early in infancy from intercurrent infection. Therapy is mainly symptomatic. Numerous operations have been devised but none is of consistent value.

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ACKNOWLEDGEMENT

I wish to express my gratefulness to Professor E. Glanzmann for his assistance and guidance in the preparation of this work.

L.C.